

CLAIMS:

- 1 1. A method of suppressing side lobe interference in a beamforming process, the method
- 2 comprising:
- 3 receiving a plurality of sensor signals comprising elemental data;
- 4 forming a main beam comprised of main beam samples using all of the sensor
- 5 signals;
- 6 combining a subset of the sensor signals into signal pairs;
- 7 calculating a complex weighting factor for each signal in a pair such that the
- 8 maximum response axis of the resulting signal pair combination is aligned with the
- 9 maximum response axis of the main beam;
- 10 assigning opposite amplitudes to each signal in the pair to produce delta-channel
- 11 auxiliary signals having zero response along the maximum response axis;
- 12 computing a covariance matrix, M , using the delta-channel auxiliary signals;
- 13 computing a cross-covariance vector, Λ , using the delta-channel auxiliary signals and
- 14 the main beam;
- 15 computing a vector of delta-channel auxiliary signal weights;
- 16 multiplying each sample from each delta-channel auxiliary signal by its
- 17 corresponding weight to yield weighted delta-channel auxiliary signals;
- 18 summing the weighted delta-channel auxiliary signals to obtain suppressor channel
- 19 samples; and
- 20 subtracting the suppressor channel samples from the main beam samples to obtain an
- 21 interference-free main beam.

1 2. The method of claim 1 wherein the signal pairs are comprised of signals from sensors
2 that are adjacently located near the edges of the array.

1 3. The method of claim 1 wherein each member of the covariance matrix, M , is an
2 estimate of the covariance between two delta-channel auxiliary signals such that the whole
3 matrix contains estimates of every possible delta-channel auxiliary signal combination and
4 the main diagonal of the covariance matrix contains the variance of the corresponding delta-
5 channel auxiliary signal.

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1 4. The method of claim 3 wherein the covariance matrix, M , is calculated according to:

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$$3 \quad M = \frac{1}{N} (A \cdot A^H).$$

4

5 where,

6 the delta-channel auxiliary signal samples are arranged along columns in a matrix A ;

7 N is the number of samples; and

8 H denotes combined conjugation and transposition.

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1 5. The method of claim 4 wherein the samples from the main beam are arranged in a
2 column vector, B_0 , and the cross-covariance vector, Λ , is calculated according to:

$$3 \quad \Lambda = \frac{1}{N} (A \cdot B_0^H).$$

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- 1 6. The method of claim 5 wherein the delta-channel auxiliary signal weights are
2 calculated according to:

3

$$4 \quad w = (M^{-1} \Lambda)^*$$

5

- 6 where the (*) symbol denotes conjugation.

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- 1 7. The method of claim 1 further comprising:
2 applying an element-by-element weighting to the elemental data to adjust the
3 maximum response axis of the array of sensors and to reduce array sidelobe levels.

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- 1 8. A system for suppressing side lobe interference in a beamforming process, the system
2 comprising:

3 means for receiving a plurality of sensor signals comprising elemental data;

4 means for forming a main beam comprised of main beam samples using all of the
5 sensor signals;

6 means for combining a subset of the sensor signals into signal pairs;

7 means for calculating a complex weighting factor for each signal in a pair such that
8 the maximum response axis of the resulting signal pair combination is aligned with the
9 maximum response axis of the main beam;

10 means for assigning opposite amplitudes to each signal in the pair to produce delta-
11 channel auxiliary signals having zero response along the maximum response axis;

12 means for computing a covariance matrix, M , using the delta-channel auxiliary
 13 signals;
 14 means for computing a cross-covariance vector, Λ , using the delta-channel auxiliary
 15 signals and the main beam;
 16 means for computing a vector of delta-channel auxiliary signal weights;
 17 means for multiplying each sample from each delta-channel auxiliary signal by its
 18 corresponding weight to yield weighted delta-channel auxiliary signals;
 19 means for summing the weighted delta-channel auxiliary signals to obtain suppressor
 20 channel samples; and
 21 means for subtracting the suppressor channel samples from the main beam samples to
 22 obtain an interference-free main beam.

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1 9. The system of claim 8 wherein the signal pairs are comprised of signals from sensors
 2 that are adjacently located near the edges of the array.

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1 10. The system of claim 8 wherein each member of the covariance matrix, M , is an
 2 estimate of the covariance between two delta-channel auxiliary signals such that the whole
 3 matrix contains estimates of every possible delta-channel auxiliary signal combination and
 4 the main diagonal of the covariance matrix contains the variance of the corresponding delta-
 5 channel auxiliary signal.

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1 11. The system of claim 10 wherein the covariance matrix, M , is calculated according to:

2

$$3 \quad M = \frac{1}{N} (A \cdot A^H).$$

4

5 where,

6 the delta-channel auxiliary signal samples are arranged along columns in a matrix A ;

7 N is the number of samples; and

8 H denotes combined conjugation and transposition.

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1 12. The system of claim 11 wherein the samples from the main beam are arranged in a

2 column vector, B_0 , and the cross-covariance vector, Λ , is calculated according to:

$$3 \quad \Lambda = \frac{1}{N} (A \cdot B_0^H).$$

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1 13. The system of claim 12 wherein the delta-channel auxiliary signal weights are

2 calculated according to:

3

$$4 \quad w = (M^{-1} \Lambda)^*$$

5

6 where the (*) symbol denotes conjugation.

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1 14. The system of claim 8 further comprising:
2 means for applying an element-by-element weighting to the elemental data to adjust
3 the maximum response axis of the array of sensors and to reduce array sidelobe levels.

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1 15. A system for suppressing side lobe interference in a beamforming process
2 comprising:
3 a processor readable storage medium;
4 code recorded in the processor readable storage medium to receive a plurality of
5 sensor signals comprising elemental data;
6 code recorded in the processor readable storage medium to form a main beam
7 comprised of main beam samples using all of the sensor signals;
8 code recorded in the processor readable storage medium to combine a subset of the
9 sensor signals into signal pairs;
10 code recorded in the processor readable storage medium to calculate a complex
11 weighting factor for each signal in a pair such that the maximum response axis of the
12 resulting signal pair combination is aligned with the maximum response axis of the main
13 beam;
14 code recorded in the processor readable storage medium to assign opposite
15 amplitudes to each signal in the pair to produce delta-channel auxiliary signals having zero
16 response along the maximum response axis;
17 code recorded in the processor readable storage medium to compute a covariance
18 matrix, M , using the delta-channel auxiliary signals;
19 code recorded in the processor readable storage medium to compute a cross-

20 covariance vector, Λ , using the delta-channel auxiliary signals and the main beam;
21 code recorded in the processor readable storage medium to compute a vector of delta-
22 channel auxiliary signal weights;
23 code recorded in the processor readable storage medium to multiply each sample
24 from each delta-channel auxiliary signal by its corresponding weight to yield weighted delta-
25 channel auxiliary signals;
26 code recorded in the processor readable storage medium to sum the weighted delta-
27 channel auxiliary signals to obtain suppressor channel samples; and
28 code recorded in the processor readable storage medium to subtract the suppressor
29 channel samples from the main beam samples to obtain an interference-free main beam.

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1 16. The system of claim 15 wherein the signal pairs are comprised of signals from
2 sensors that are adjacently located near the edges of the array.

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1 17. The system of claim 15 wherein each member of the covariance matrix, M , is an
2 estimate of the covariance between two delta-channel auxiliary signals such that the whole
3 matrix contains estimates of every possible delta-channel auxiliary signal combination and
4 the main diagonal of the covariance matrix contains the variance of the corresponding delta-
5 channel auxiliary signal.

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1 18. The system of claim 17 wherein the covariance matrix, M , is calculated according to:

2

$$3 \quad M = \frac{1}{N} (A \cdot A^H).$$

4

5 where,

6 the delta-channel auxiliary signal samples are arranged along columns in a matrix A ;

7 N is the number of samples; and

8 H denotes combined conjugation and transposition.

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1 19. The system of claim 18 wherein the samples from the main beam are arranged in a

2 column vector, B_0 , and the cross-covariance vector, Λ , is calculated according to:

$$3 \quad \Lambda = \frac{1}{N} (A \cdot B_0^H).$$

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1 20. The system of claim 19 wherein the delta-channel auxiliary signal weights are

2 calculated according to:

3

$$4 \quad w = (M^{-1} \Lambda)^*$$

5

6 where the (*) symbol denotes conjugation.

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1 21. The system of claim 15 further comprising:

2 applying an element-by-element weighting to the elemental data to adjust the

1 18. The system of claim 17 wherein the covariance matrix, M , is calculated according to:

2

$$3 \quad M = \frac{1}{N} (A \cdot A^H).$$

4

5 where,

6 the delta-channel auxiliary signal samples are arranged along columns in a matrix A ;

7 N is the number of samples; and

8 H denotes combined conjugation and transposition.

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1 19. The system of claim 18 wherein the samples from the main beam are arranged in a

2 column vector, B_0 , and the cross-covariance vector, Λ , is calculated according to:

$$3 \quad \Lambda = \frac{1}{N} (A \cdot B_0^H).$$

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1 20. The system of claim 19 wherein the delta-channel auxiliary signal weights are

2 calculated according to:

3

$$4 \quad w = (M^{-1} \Lambda)^*$$

5

6 where the (*) symbol denotes conjugation.

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1 21. The system of claim 15 further comprising:

2 applying an element-by-element weighting to the elemental data to adjust the

3 maximum response axis of the array of sensors and to reduce array sidelobe levels.

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